

Translational Behavior Analysis: From Laboratory Science in Stimulus Control to Intervention with Persons with Neurodevelopmental Disabilities

William J. McIlvane

University of Massachusetts Medical School and Shriver Center

Throughout its history, laboratory research in the experimental analysis of behavior has been successful in elucidating and clarifying basic learning principles and processes in both humans and nonhumans. In parallel, applied behavior analysis has shown how fundamental behavior-analytic principles and procedures can be employed to promote desirable forms of behavior and to prevent or ameliorate undesirable forms in clinical, educational, and other settings. Less obviously, there has also emerged a small but identifiable bridging field that can potentially connect and inform both basic and applied behavior analysis. Although such translational behavior analysis uses laboratory methodologies, research targets are selected largely for their value in ultimate application to improve the human condition. I will discuss the distinction of translational behavior analysis from basic and applied behavior analysis and consider the potential contribution that translational research can make in the development of the science of behavior.

Key words: translational research, stimulus control, neurodevelopmental disabilities, basic research

What is Translational Research?

People who received their training prior to about 15 to 20 years ago may have never heard the term *translational research* during their studies. Activities within the scientific enterprise were typically categorized as either basic science or applied science. The former was conducted mainly to develop new knowledge about the natural world, whereas the latter was conducted to improve some aspect of the human condition. By contrast, people who have received their training more recently would find use of *translational research* ubiquitous, especially if that training was received in an environment that was even distantly connected to medical re-

search. Indeed, such research, which occupies a conceptual space between basic research and applied research, has become a priority at the highest levels of science and medicine. In parlance common to the National Institutes of Health (NIH), translational research is defined as the process of applying ideas, insights, and discoveries generated through basic scientific inquiry to the treatment or prevention of human disease. Among the most important recent developments at the NIH, for example, has been the reconceptualization of its longstanding General Clinical Research Centers as a program of Clinical and Translational Science Awards (CTSAs) designed to advance translational research at the nation's most prestigious medical centers (Morrison, 2008).

Translational Behavior Analysis?

We have argued elsewhere that there is utility in defining *translational behavior analysis* as an identifiable subfield of behavior analysis. Our thinking is similar to that of Wacker (1996, 2003) and follows the earlier

The main research program described here has had long-term support from the National Institutes of Child Health and Human Development, most recently NICHD Grants HD04147, HD25995, and HD52947. The work in Brazil was supported by CNPq Grant 479436/2003-7 and by FAPESP Grant 2003/09928-4.

Address correspondence to William J. McIlvane, UMMS Shriver Center, 333 South Street, Shrewsbury, Massachusetts 01545 (e-mail: william.mcilvane@umassmed.edu).

thinking of Hake (1982), who was the first to my knowledge to emphasize the value of what he termed *bridge* studies. Briefly, Wacker (2003) identified bridge studies "as the cornerstone for applied behavior analysis ... because they bridge information on the basic mechanisms that underlie responding to the applications of those mechanisms" (p. 405). I am particularly drawn to Hake's conception of behavior analysis as representing a continuum of effort with pure basic and pure applied research as the logical endpoints and activities with features of both as occupying points along this continuum.

In identifying translational behavior analysis as a subfield of behavior analysis, my intent here is to align behavior-analytic classification of research with that ongoing in other branches of the biomedical and behavioral sciences. If translational research is to be elevated to priority status across the board, as reflected in current NIH activity, then it seems to be in the interests of behavior analysts to follow suit. Developing Hake's (1982) point further, one can persuasively argue that the foundations of behavior analysis are inherently consistent with the development of translational science perspectives: Early on, Skinner took it upon himself to link his fundamental basic research (Skinner, 1938) to potential research translation and application (Skinner, 1953, 1957).

Differentiating Basic, Translational, and Applied Behavior Analysis

I think that typical readers of *The Behavior Analyst* will have little difficulty in differentiating basic from applied behavior analysis. Many articles that appear in the *Journal of the Experimental Analysis of Behavior* would never find acceptance as articles appropriate for publication in the *Journal of Applied Behavior Analysis* (JABA) and vice versa. I speculate, however, that translational behavior

analysis as a concept will present a classification challenge for many behavior analysts, perhaps especially those whose activities are strongly associated with applied behavior analysis. I base my speculation on experience with editorial processes in JABA, where it seems that enthusiasm for translational behavior analysis studies can vary from editor to editor and from reviewer to reviewer. As a practical matter, translational behavior analysts from my research group are sometimes unsure where to send their research reports.

Very recently, our group has taken on the challenge of precisely differentiating translational behavior analysis from applied behavior analysis (McIlvane et al., in press). We have pointed out the similarity in objective (i.e., improvement of the human condition) while also noting many obvious differences, among them (a) the nature of participants targeted, (b) primary research objectives, (c) time frame of planned and valued benefit, (d) characteristics of delivery systems for developed behavioral technology, (e) typical research environments, (f) dissemination outlets, and (g) source of resources to support the work.

We hope that the process of identifying translational behavior analysis as a directly related class of activities will aid in developing broader recognition by applied behavior analysts that such activities have a useful, perhaps irreplaceable role in informing activities in clinical, educational, and other intervention settings. The focus of recent work at the Shriver Center has been translational behavior analysis as it pertains to understanding and potentially ameliorating behavioral deficits of persons with autism and related neurodevelopmental disabilities. This work will provide the context for illustrating and explaining translational behavior analysis in contemporary practice.

Translational Research Control of Behavioral Variability

In overview, the Shriver program has been and continues to be directed to the challenge of establishing prerequisites for functional communication and other forms of desirable behavior in persons with neurodevelopmental disabilities. Murray Sidman and his colleagues launched the program more than 40 years ago (e.g., Sidman & Stoddard, 1966). Then as now, its core objective has been the management of behavioral variability of its target population. Many principals of the current program were Sidman students, directly or indirectly. Thus, we have grown up with his challenge to manage behavioral variability procedurally (rather than merely statistically), a challenge he posed originally as a core objective of behavioral science in *Tactics of Scientific Research* (Sidman, 1960).

Notably, Sidman's (1960) challenge is similar in kind to that faced every day by clinicians and educators in the behavioral heterogeneity in their clients or students. Within even reasonably well-defined diagnostic categories such as the autism spectrum disorders, for example, behavior therapists address at least five diagnostic entities with somewhat different behavioral characteristics. Historically, our work has addressed primarily the more challenging end of the autism spectrum, where the behavioral heterogeneity is substantial and likely has its roots in interaction of the biological substrate with environmental contingencies (Miles et al., 2005). Although such disabilities have been characterized fairly well at the descriptive level, their determinants and modifiability remain priority topics for translational and applied research.

One of the key distinctions between contemporary translational and applied research in practice is one's perspective on the purpose of

research with individual participants. Although both research traditions typically feature predominant use of single-subject designs, the goals can be different. Often, the applied behavior analyst is mainly interested in changing the behavior of selected individuals in a therapeutic or educational situation for the better. Application of behavioral principles to do so typically defines success. By contrast, the translational behavior analyst tends to be concerned to a greater degree about the characteristics of the research participant as a representative of a larger group or groups of participants. To be sure, success with individuals is a goal, but the translational behavior analyst is concerned also in defining the range of individuals who can benefit from a given intervention. We will illustrate this concern with reference to one of our major research initiatives of the past several decades—the degree to which individuals with little or no language have the potential to exhibit true symbolic relations as opposed to simple rote learning that lacks any generative properties.

Stimulus equivalence research. Questions about symbolic processes and potential of individuals with limited language abound in the history of psychology and related fields. There has been a rich tradition in developmental psycholinguistics (e.g., Kagan, 1981; Mervis & Bertrand, 1993). Many of the same issues have been addressed in animal cognition research, for example, with nonhuman primates (e.g., Cerutti & Rumbaugh, 1993), marine mammals (Schusterman & Kastak, 1993), and pigeons (e.g., Zentall & Uruioli, 1993). Within the field behavior analysis, Sidman and Tailby (1982) offered a uniquely well-defined operational definition for differentiating symbolic from rote relations, suggesting that only the former were relations of *equivalence*, as defined in mathematical logic. Most commonly, equivalence relations are operationalized in

symbolic (or arbitrary) matching to sample (MTS). Matching relations are equivalence relations if they have the properties of reflexivity, symmetry, and transitivity.

For more than two decades, research by a number of prominent behavior-analytic groups has sought to demonstrate that stimulus equivalence as defined by Sidman and Tailby (1982) is demonstrable (or not) in individuals without language (e.g., Carr, Wilkinson, Blackman, & McIlvane, 2000; Devany, Hayes, & Nelson, 1986; Horne & Lowe, 1996; Schusterman & Kastak, 1993). Recognizing that not all of my colleagues will agree with me, I think that today's issue is not whether stimulus equivalence may be demonstrable in nonverbal individuals but rather whether methods of behavior analysis can render positive outcomes reliably within and across individuals, perhaps including nonhumans.

Regarding research translation specifically, I can point to a sustained effort over more than two decades to ascertain whether generalized identity MTS (Sidman's specified test for reflexivity in matching relations) (a) could be established reliably in the very heterogeneous population of persons with autism and related neurodevelopmental disabilities and (b) could serve as a model for classroom procedures with the same objective. When the program was launched around 1989, the extant behavioral technology could establish generalized identity MTS in perhaps 30% of children with mental ages ≤ 3.0 years (Serna, Dube, & McIlvane, 1997). The research goal was to extend the technology such that almost any child who could be taught to discriminate simple forms, including nonverbal children, could be taught also generalized identity MTS. This translational research program produced numerous publications that documented various component behavioral analyses. By 1999, major effort on this problem

was suspended, because virtually all of the key scientific problems that initiated it had been solved. The critical finding was the near-universal success with minimally verbal and nonverbal children, some with straightforward programmed instruction and others via complex, multidimensional training. Within this related problem area, therefore, interindividual variability was managed and virtually eliminated via a sustained program of behavior analysis. That program is now at the end point of its translational research cycle. We are currently field testing a software-based delivery system by which this mature behavioral technology can be delivered to the classroom.

Influence of Bidirectional Translational Research

In my opinion, the NIH consensus definition mentioned earlier is unnecessarily limiting, in that it implies a unidirectional rather than a bidirectional flow of information and influence (i.e., from the laboratory to the intervention setting). Although some basic researchers do think this way in my experience, others initiate and sustain scientific careers at least in part because they have a vision of research translation and application to solve human problems. For the latter, the bridge goes both ways (cf. Mace, 1994). Research topics, methods, and strategies are selected in part to foster (or at least not preclude) translation. In turn, translational goals may be influenced by the practical realities of application research and, ultimately, intervention practice.

One example of the latter influence occurred recently as Shriver researchers jointly pursued a translational research initiative with collaborators at the Universidade Federal de São Carlos in Brazil. All involved are pointing their research to ultimate applications, especially in the special education classroom (e.g., de Souza

et al., 2009). One part of the joint initiative has been an effort to align procedures from laboratory research with those operative in the classroom whenever possible and to bring evolved classroom methodologies back to the laboratory, with the goal of improving both laboratory and classroom procedures.

As background to the example, when observing activities in the classroom, one notes that laboratory-derived methods such as MTS are often supplemented with or replaced by methods that are more convenient to implement for teachers who work in one-to-one interactions. In the domain of identity relations particularly, sorting procedures are often used as alternatives to MTS. The student is given, for example, two classes of stimuli to sort into two groups (e.g., plastic forks and spoons). The student is free to sort the stimuli in any order (e.g., perhaps collecting all of the forks before turning to the spoons).

As one observes students sorting items rapidly and reliably, one may be struck with the facility with which this is done, especially if the student is having difficulty mastering identity MTS. Although one might attribute facile sorting to prior undocumented teaching and practice, laboratory research suggests good reasons why sorting might prove easier to learn than identity matching. Typical MTS procedures require both successive discriminations (between the sample stimuli) and simultaneous discriminations (between the comparison stimuli), and the former tend to be more challenging to acquire than the latter (cf. Saunders & Spradlin, 1989). By contrast, typical sorting procedures present all of the stimuli to be discriminated simultaneously. Further, typical MTS procedures have the familiar fixed-trial structure that has remained largely unchanged since the early days of behavior analysis (e.g., Skinner, 1950). Samples are presented one at a time, and trials are separated by intertrial

intervals. By contrast, sorting procedures allow the participant much greater flexibility in choosing among the stimuli, allowing him or her, for example, to select many of the *same* items until all are exhausted without necessarily imposing an intertrial interval between them.

Recently, our Brazilian colleagues conducted a study that was aimed at importing some of the features of classroom sorting procedures into a fixed-trial identity matching procedure (Gomes & de Souza, 2008). The participants were 20 individuals with autism of varying levels of severity as assessed by the Childhood Autism Rating Scale (Schopler, Reichler, DeVellis, & Daly, 1980), 8 of whom were characterized as nonverbal. They were interested primarily in the facility with which one might initially secure an identity-matching baseline. They compared (a) a simultaneous procedure in which three sample stimuli were presented simultaneously on each MTS trial, and the participants were allowed to respond to three simultaneously displayed comparison stimuli in any order as in a sorting procedure and (b) a successive procedure that presented sample and comparison stimuli in the manner typical of laboratory-implemented MTS trials.

Figure 1 shows results from two conditions. Initially, the simultaneous and successive procedures were presented in separate trial blocks. Thereafter, simultaneous and successive trial types were intermixed in the same trial block. The simultaneous procedure was superior (both by eye and statistically) to the typical successive procedure in both the separate and the intermixed conditions. These data were further analyzed in relation to verbal functioning and degree of autism. Data in Figure 2 are plotted as the percentage of participants who showed higher, lower, or equal scores on the simultaneous protocol compared to the successive protocol. Figure 2 (top) shows that nonverbal

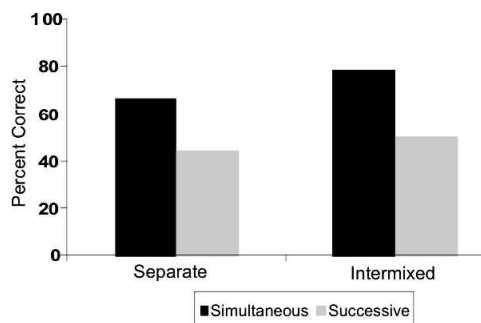


Figure 1. Histogram presentation of group data resulting from comparison of simultaneous and successive procedures reported by Gomes and de Souza (2008).

participants virtually always exhibited superiority in that condition. Much the same was true for participants with severe autism (Figure 2, bottom). The same trend was shown by participants with better developed verbal repertoires and less severe autism, but the magnitude of the differences was lower (data not shown).

This little study may contain a big lesson for researchers who are interested in translational topics. It seems possible, perhaps even likely, that the time necessary to develop our successful identity-matching training program could have been shortened through a merger of our laboratory methods and their underlying analyses with evolved classroom procedures that had similar objectives. The benefit here would clearly be bidirectional, potentially informing both more efficient laboratory procedures and more effective applications of them.

Use of Animal Models in Translational Behavior Analysis

I conclude by addressing another clear area of research need, the development of animal models of neurodevelopmental disabilities as a potential aid in developing and evaluating both biomedical and behavioral interventions for affected individuals (McIlvane & Cataldo, 1996). In biomedical research, the use of model systems is ubiquitous and

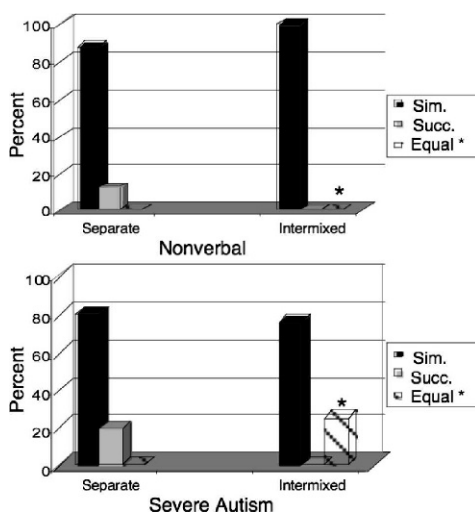


Figure 2. Histogram presentation of results from Gomes and de Souza (2008) analyzed to separate procedure comparisons involving nonverbal children (top) and those with severe autism (bottom).

virtually universally accepted. In basic neuroscience, for example, studies of fruit flies, sea slugs, mice, and rats are used to uncover the biological foundations of learning and memory that are intended to extend all of the way to human functioning.

The situation seems somewhat different in the behavioral sciences. Everyone acknowledges that the foundational principles of behavior analysis derive from animal behavior studies. That said, I think that the present relation between basic laboratory studies with nonhumans and the world of applied behavior analysis is not as close as it might beneficially be. Particularly lacking, in my view, has been attention to explicit animal modeling of the behavioral characteristics of neurodevelopmental disorders using behavior-analytic methodology. This enterprise seems to have been largely ceded to behavioral neuroscientists, whose impressive methodological development tends to make only limited use of the rich methodological foundations of behavior analysis (e.g., Crawley, 2000).

Why have behavior analysts largely ignored modeling of neurodevelop-

mental disabilities when its foundations rest on animal behavior studies of behavioral processes that are presumed to be preserved also in humans? I attribute this disconnect in part to the fact that translational behavior analysis as a field, and its bridging function, has not been recognized as such by many behavior analysts. Basic behavior analysis proceeds as an academic discipline in an ever-dwindling number of supportive universities. In parallel, applied behavior analysis programs continue to evolve in a growing number of locations as a largely clinical discipline in which the connection to basic research, particularly research with nonhumans, is often remote to nonexistent. Translational behavior analysis, identified as such, may have the potential to rescue the basic programs from deemed irrelevancy by university administrators and may inform applied programs with the high-quality information that rigorous laboratory methodologies can offer, especially if they are pointed in the right direction.

REFERENCES

- Carr, D., Wilkinson, K. M., Blackman, D. E., & McIlvane, W. J. (2000). Equivalence classes in individuals with minimal verbal repertoires. *Journal of the Experimental Analysis of Behavior*, 71, 101–114.
- Cerutti, D. C., & Rumbaugh, D. M. (1993). Stimulus relations in comparative primate perspective. *The Psychological Record*, 43, 811–821.
- Crawley, J. N. (2000). *What's wrong with my mouse? Behavioral phenotyping of transgenic and knockout mice* (2nd ed.). New York: Wiley.
- de Souza, D. G., de Rose, J. C., Faleiros, T. C., Bortoloti, R., Hanna, E. S., & McIlvane, W. J. (2009). Teaching generative reading via recombination of minimal textual units: A legacy of *Verbal Behavior* to children in Brazil. *International Journal of Psychology and Psychological Therapy*, 9, 19–44.
- Devany, J. M., Hayes, S. C., & Nelson, R. O. (1986). Equivalence class formation in language-able and language-disabled children. *Journal of the Experimental Analysis of Behavior*, 46, 243–257.
- Gomes, C. G. S., & de Souza, D. G. (2008). Desempenho de pessoas com autismo em tarefas de emparelhamento com o modelo por identidade: Efeitos da organização dos estímulos. *Psicologia: Reflexão e Crítica*, 21, 412–423.
- Hake, D. F. (1982). The basic-applied continuum and the possible evolution of human operant social and verbal research. *The Behavior Analyst*, 5, 21–28.
- Horne, P. J., & Lowe, C. F. (1996). On the origins of naming and other symbolic behavior. *Journal of the Experimental Analysis of Behavior*, 65, 185–241.
- Kagan, J. (1981). *The second year: The emergence of self-awareness*. Cambridge, MA: Harvard University Press.
- Mace, F. C. (1994). Basic research needed for stimulating the development of behavioral technologies. *Journal of the Experimental Analysis of Behavior*, 61, 529–550.
- McIlvane, W. J., & Cataldo, M. (1996). On the clinical relevance of animal models for the study of human mental retardation. *Mental Retardation Developmental Disabilities Research Review*, 3, 188–196.
- McIlvane, W. J., Dube, W. V., Lionello-DeNolf, K. M., Serna, R. W., Barros, R. S., & Galvão, O. F. (in press). Some current dimensions of translational behavior analysis: From laboratory research to intervention for persons with autism spectrum disorders. In J. Mulick & E. Mayville (Eds.), *Behavioral foundations of effective autism treatment*. Cambridge, MA: Cambridge Center for Behavioral Studies.
- Mervis, C. B., & Bertrand, J. (1993). Acquisition of early object labels: The roles of operating principles and input. In A. P. Kaiser & D. B. Gray (Eds.), *Enhancing children's communication* (Vol. 2, pp. 287–316). Baltimore: Brookes.
- Miles, J. H., Takahashi, T. N., Bagby, S., Sahota, P. K., Vaslow, D. F., Wang, C. H., et al. (2005). Essential versus complex autism: Definition of fundamental prognostic subtypes. *American Journal of Medical Genetics Part A*, 135(2), 171–180.
- Morrison, L. (2008). The CTSAs, the Congress, and the scientific method. *Journal of Investigative Medicine*, 56, 7–10.
- Saunders, K. J., & Spradlin, J. E. (1989). Conditional discrimination in mentally retarded adults: The effects of training the component simple discriminations. *Journal of the Experimental Analysis of Behavior*, 52, 1–12.
- Schopler, E., Reichler, R. J., DeVellis, R. F., & Daly, K. (1980). Toward objective classification of childhood autism: Childhood Autism Rating Scale (CARS). *Journal of Autism and Developmental Disorders*, 10, 91–103.
- Schusterman, R. J., & Kastak, D. (1993). A California sea lion (*Zalophus californianus*) is capable of forming equivalence relations. *The Psychological Record*, 43, 823–844.
- Serna, R. W., Dube, W. V., & McIlvane, W. J. (1997). Assessing same/different judgments in individuals with severe intellectual dis-

- abilities: A status report. *Research in Developmental Disabilities*, 18, 343–368.
- Sidman, M. (1960). *Tactics of scientific research: Evaluating experimental data in psychology*. Boston: Authors Cooperative.
- Sidman, M., & Stoddard, L. T. (1966). Programming perception and learning for retarded children. In N. R. Ellis (Ed.), *International review of research in mental retardation* (Vol. 2, pp. 151–208). New York: Academic Press.
- Sidman, M., & Tailby, W. (1982). Conditional discriminations vs. matching-to-sample: An expansion of the testing paradigm. *Journal of the Experimental Analysis of Behavior*, 37, 5–22.
- Skinner, B. F. (1938). *The behavior of organisms: An experimental analysis*. New York: Appleton-Century.
- Skinner, B. F. (1950). Are theories of learning necessary? *Psychological Review*, 57, 193–216.
- Skinner, B. F. (1953). *Science and human behavior*. New York: Macmillan.
- Skinner, B. F. (1957). *Verbal behavior*. New York: Appleton-Century-Crofts.
- Wacker, D. P. (1996). Behavior analysis research in *JABA*: A need for studies that bridge basic and applied research. *Experimental Analysis of Human Behavior Bulletin*, 14, 11–14.
- Wacker, D. P. (2003). Bridge studies in behavior analysis: Evolution and challenges in *JABA*. *The Behavior Analyst Today*, 3, 405–411.
- Zentall, T. R., & Urcuioli, P. J. (1993). Emergent relations in the formation of stimulus classes in pigeons. *The Psychological Record*, 43, 795–810.